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LIGHTING DATA

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE HARRISON, N. J.

Electric Light on the Farm

mg

Information compiled by
A. L. POWELL
Lighting Service Department

Synopsis

For information regarding Mazda lamps and lighting questions, refer to the nearest sales office.

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Electric Light on the Farm

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Introductory

It may be assumed that if the average individual were asked as to the type of lighting he would prefer for his home or factory, he would without hesitancy answer, electric. Electric service offers even greater opportunities to the farmer than to the city dweller. With it he has not only light whenever and wherever needed but also a most convenient and efficient means of cutting grain, feed and wood; grinding bone and seed; operating butter workers, churns, cream separators, milk pasteurizers, milk testers and milking machines; pumping water for stock and irrigation; candling and testing eggs; heating incubators and brooders; shearing sheep; grooming and clipping horses, and a hundred and one other uses.

In addition to the convenience of electric lighting about the farm, there is a special advantage, that of safety. Due to the remote position of the farm a fire usually results in a total loss of buildings and stock. The upsetting of a lantern by the hired man while doing the chores after nightfall is a very common cause of fires.

The housewife will especially appreciate the advantages of electricity and the time saved with no kerosene lamps to clean, fill and trim is a worth-while consideration.

Electricity makes the farm a more comfortable and attractive place on which to live and work, has the advantage of attracting desirable labor and the tendency to keep the young people on the farm.

Sources of Power Supply

In the large city or town, the consumer of electricity has at his disposal two sources of electric current; the first, central station supply; the second, a private or isolated plant installed in his building or factory. It has been found in the great majority of cases, that it is more economical to buy current from the central station than to attempt to generate it in small quantities. Of course, there may be exceptions to this, dependent on local conditions.

A somewhat analogous condition exists in regard to farms. The farmer may purchase electric current from a central station, or may install an isolated or private plant. There is this difference, however; central station lines in many instances do not extend far into

the country, touching these widely separated farm areas, making it absolutely necessary for the farmer, if he is to have the advantages of electric service, to install his own plant. In those cases, however, where the farm is within a reasonable distance of the central station distribution or high tension service lines, it is generally more economical to buy current, rather than attempt to operate a small private plant and have the attendant annoyance of maintenance and repairs.

It is a relatively expensive matter to construct a pole line serving a customer at a rather distant point, and it can hardly be asked of a central station to finance such outlying lines which are unlikely to have very large power demands. There are a number of schemes which have been used for financing such extensions.

An analysis of the situation reveals that it is good business for the farmer to co-operate with the supply company in financing the new extensions, rather than going to the expense of installing his own plant. Many individuals, feeling that they are dealing with a large corporation, are hesitant about such a step, yet a careful analysis indicates the logic of this method of procedure.

As mentioned, several methods have been used in the rural line development where customers are served as individuals. In some cases the customer provides all or part of the money for constructing the line, under other conditions this is financed by the utility. Various rates, service charges and energy charges are provided for the different cases, but space does not permit a discussion of relative merits. It is sufficient to say that the rural customer should co-operate in this matter for the utility renders him a real service.

Where service from a utility is quite out of the question, use may be made of the compact and relatively efficient farm light and power plants. There are many types of these on the market of various sizes, operating on different principles, and with certain advantages and disadvantages. Any plant designed for this service should be as simple as is possible to make it, for the average layman, knowing comparatively little about engines and electric generators, does not care to spend time in making adjustments and maintaining the plant.

The farm lighting plant consists in general of an engine, a generator, a control board, and a battery.

Various forms of engines are used employing gasoline, kerosene, alcohol or natural gas. They operate on the same principles as the standard automobile engine.

The size of generator depends, of course, on the amount of load which is to be attached to the system. They are made in various voltages from 32 to 110. The 32-volt system has become quite generally popular, for it requires but 16 lead storage battery cells. The 110-volt system, however, permits the use of standard 110-volt lamps, appliances and motors, which can be obtained from any electrical dealer, and are generally lower in first cost than the somewhat special low volt appliances.

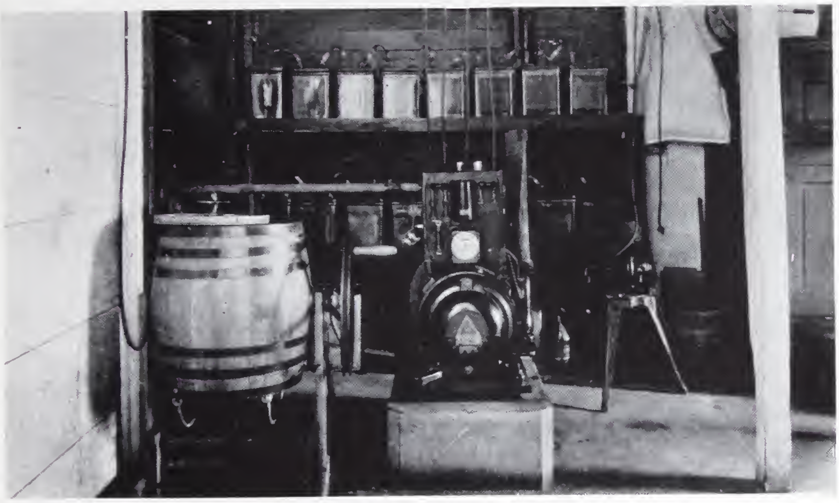

FIG. 1
A Typical Farm Lighting Set Consisting of a Gasoline Engine, Generator, Switchboard and Lead Plate, 16-cell, 32-volt Storage Battery

Both the lead cell and the nickel steel types of storage batteries are used; the former is lower in first cost, while the latter is much more simple in maintenance and has a longer life. The size of the battery will depend on the amount of current which will be required by the system, and the number of cells, of course, on the voltage of the system.

The control board contains the fuses, circuit breakers, switches and other devices for protecting the equipment. Where a battery is used an ampere-hour meter indicating the state of charge of the battery is a necessary device. With one system use is made of a 110-volt direct-current generator having no battery. The switchboard is so arranged that the engine and generator start automatically when any lamp is turned on, and stop automatically when the load is removed.

In other systems, 32- or 64-volt generators are used with a storage battery. See Fig. 1. In some cases these are started by pushing a button on the panelboard and stop automatically when the battery is charged. In other cases engine and generator start automatically when a certain state of discharge is reached.

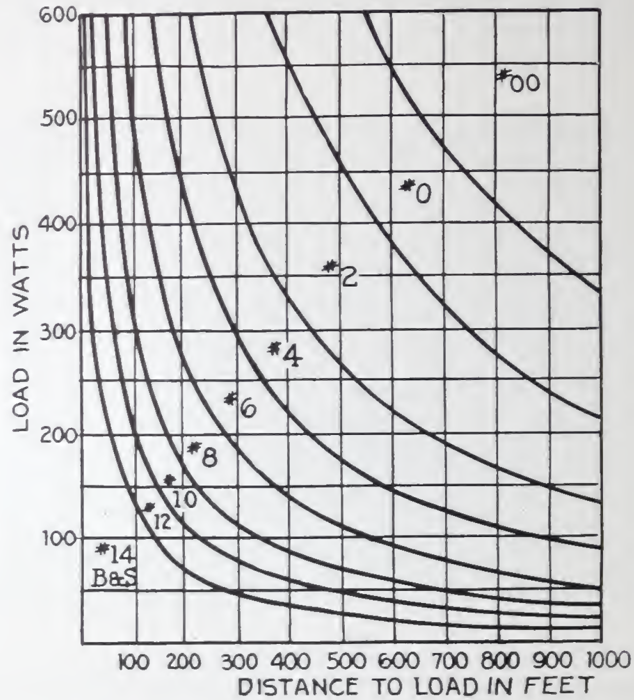

FIG. 2

Chart Indicating the Size of Wire Necessary for Various Loads Transmitted Different Distances with a 2-volt Drop on the 28/32-volt System

Wiring

In the larger towns and cities inspection by municipal authorities and the fire insurance companies necessitate a relatively high standard of wiring. On the farm, however, where there is not this close supervision, there is likely to be a tendency to install inferior wiring. This is a practice to be deplored.

In the first place satisfactory service from the standpoint of convenience requires the use of good materials, well installed.

In the second place, the elements of protection and safety should make necessary wiring in accordance with the Underwriters Codes which have been given much careful thought.

The same attention should be given to the location of outlets and the choice of fixtures and lighting equipment, as would be the case in the city homes. It is safe to assume that the farmer will not be permanently satisfied with drop cords and bare lamps instead of regular well designed fixtures in spite of what he might feel at first. An inferior installation is very poor business indeed.

With the low-voltage system, such as used with the typical farm lighting plant, special attention must be given the size of wire. When one realizes that a lamp which gives its full light at 30 volts will give only about 77 per cent at 28 volts, and 61 per cent at 26 volts, it at once becomes apparent that it is of utmost importance that the drop in voltage should be minimized. A 2-volt drop on a 30-volt lamp is as serious as an 8-volt drop on a 110-volt lamp.

Another feature which makes it necessary to use much heavier wiring with the low-voltage system is the large current required by various lamps and appliances in comparison with 110-volt devices. A 100-watt lamp operating at 110 volts uses about 1 ampere of current, while a 100-watt lamp operating at 30 volts uses over 3 amperes of current.

The drop in a given size of wire is proportional to the current. So these two factors are cumulative. The size of wire should be such that with full load the drop will not exceed 2 volts when the low-voltage system is used. The chart shown in Fig. 2 will be of assistance in determining the size of wire to be installed.

A wiring installation for a 28/32-volt system with insulation meeting standard 110-volt specifications can be readily transferred to the higher voltage at any time, whereas a system of wiring for 110 volts would not be suitable for the lower voltage, higher current system. This feature must be carefully kept in mind, if satisfactory service is desired.

The chart shown in Fig. 3 is based on the use of the 110-volt system with an allowable voltage drop of 8 volts, and this figure is about the same in percentage value as a 2-volt drop on a low-voltage system. Comparison of the two figures is of considerable interest. For example, transmitting 500 watts a distance of 500 feet on 110-volt system, the No. 12 wire will be adequate, whereas, if 500 watts were to be transmitted 500 feet with 30-volt system, the No. 0 wire would be necessary. No. 0 wire has nearly 16 times the cross section of No. 12 wire and is proportionately that much heavier.

Lighting the House

The general subject of residence lighting is covered in considerable detail in Bulletin Index 41. The methods of lighting discussed there are of course directly applicable to the farmhouse. There is no reason whatever why the isolated position of the farm should

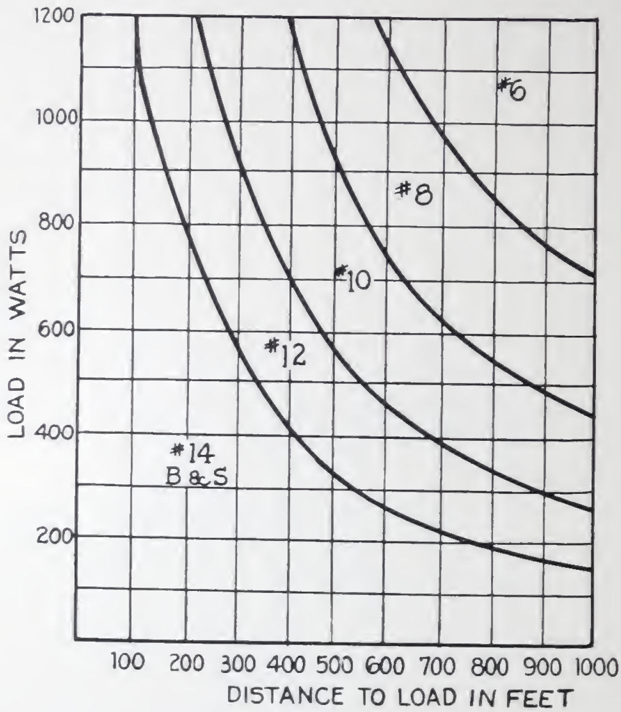

Fig. 3
Chart Indicating the Size of Wire for Various Loads Transmitted Different Distances with an 8-volt Drop on the 110-volt System

preclude the installation of modern methods. Unfortunately, there is a tendency on the part of some dealers, and mail order houses serving farming communities, to list and show types of equipment which are not thoroughly up to date.

The multi-arm chandelier and the type of fixture employing a number of small lamps is or should be a thing of the past. Where it is desired to supply general illumination for the entire room from a central unit, one should be selected which will permit the use of a single, larger, more efficient, Mazda C lamp. There are a number of such devices on the market, such as the Duplexalite, which are capable of thoroughly artistic treatment and which give most

excellent illumination results. In the kitchen, for example, the stem fixture or drop cord with a bare lamp pendant at its end, is not satisfactory for lighting. The most recent type of kitchen unit consists of an opalescent diffusing enclosing globe with a MAZDA C lamp of suitable size, 100 watts for the average kitchen, placed close to the ceiling.

In wiring the house due forethought should be exercised in providing an adequate number of convenience outlets. The statement might be made that it is almost impossible to install too many of these. Experience has proven that even where one has thought he has installed all that would ever be needed, a few months use of electricity shows other places where these would be most useful. It is a much less expensive and more simple a matter to provide the outlets when the original wiring job is being done than at a later date. Convenience outlets make it possible to use the attractive portable lamps now on the market wherever fancy dictates, as well as the innumerable electrical servants such as the vacuum cleaner, iron, washing machine, cooking devices, etc.

On the farm, where country home plants of limited capacity are used, of course somewhat different conditions are met, and greater consideration must be paid to the question of economy. It is apparent to anyone that there is a difference in efficiency of various lighting systems. Direct illumination where the most of the light is sent at once to table, book or the object which is to be illuminated, is more efficient than indirect illumination where the light is first sent to the ceiling from which it is reflected downward. On the other hand, indirect methods of illumination have many advantages such as softness and even distribution. The statement might be made that the more decorative the lighting the less the efficiency of utilization. For example, any color modification is attended by a loss. In most instances where power is relatively inexpensive and there is plenty of capacity available the pleasure accruing through a decorative lighting installation is such that one is very ready to "waste" light for a certain desired result.

Where the particular condition mentioned in the above paragraph holds, i.e., limited capacity, it is by force of circumstances necessary to use efficient devices and overlook decorative effects for the time being. As an extreme case, let us consider the type of plant which is limited to 600 watts. How should we distribute this load taking into account the manner in which the house is likely to be used, or what might be called the family habits?

In the early evening the barn, the kitchen and the dining room are probably used simultaneously; later the kitchen, dining room and living room, and still later the living room and two or more bedrooms.

Under these conditions the barn would probably have four 25-watt lamps located at the most important points. The kitchen, a 100-watt Mazda C lamp in a central fixture of the type just

Fig. 4

A Chain Suspension with a Large Fitter Supports a Wicker and Golden Brown Silk Dome Over This Dining Room Table. The light from a 50-watt white Mazda C lamp is directed downward and diffused by a white glass reflector. The entire equipment costs but little and its simplicity makes it preferable to the elaborate, ornate, glaring fixtures often used

described. (One cannot afford to be niggardly in providing light in this important room.) In the dining room a 50-watt Mazda lamp in a fixture similar to that shown in Fig. 4 will be adequate. The living room might well have the equivalent of 100 watts in a central luminaire and three 25-watt lamps in table and floor portable units. For the hall, two 15-watt lamps will provide sufficient lighting. In each of the bedrooms two 25-watt lamps properly placed, while for the cellar three 15-watt lamps will provide illumination at important points.

Lighting the Barns and Other Buildings

The safety and convenience of electricity makes it ideal for the barn and other buildings where hay and such inflammable material is stored. The mere turn of a switch at the entrance doorway floods the building with light, a feature of vital importance

Fig. 5
This Night View Indicates the Effective Lighting of a Living Room by Three 50-watt Mazda C Lamps in a Simple, Inexpensive, Opalescent Glass Semi-indirect Bowl. An adjustable fitting served from a baseboard convenience outlet provides a high intensity at the sewing machine

in times of emergency. Chores can be accomplished after nightfall without the danger, annoyance and delay of moving a light, such as a lantern, from place to place.

A lighting layout for a typical barn is shown in Fig. 6 which also indicates the size and type of lamps and reflectors for the various locations. This shows outlets above the main doors giving light for the driveway and feed bins. Other outlets close to the roof for providing illumination in the hay mows and rows of units above the runways in the rear of the stalls to be used for milking, currying and bedding are desirable.

For most of this work a low intensity of illumination will suffice. To obtain uniform distribution and avoid dense shadows where the ceiling is low, it is better to have a number of small lamps than to depend on a large, single unit.

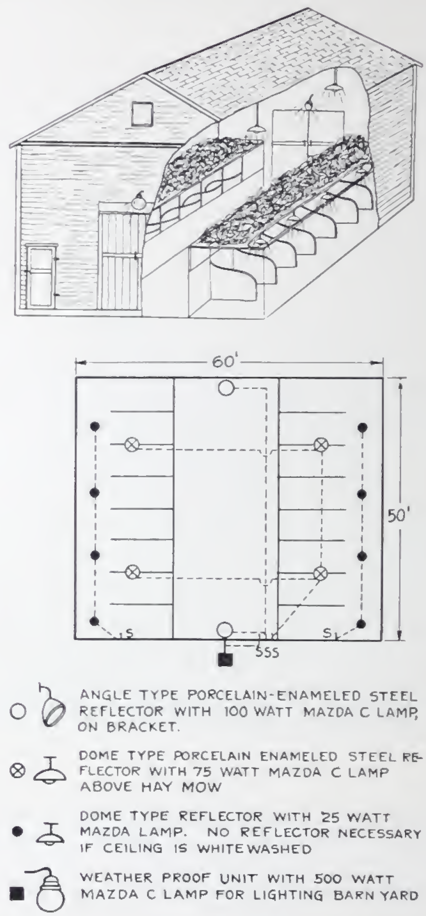

Fig. 6
Lighting Layout for a Typical Barn

A general statement might be made that each lamp should have a reflector to prevent the light being wasted, but there is an exception to this rule. If the ceiling is low and of white tile or whitewashed, then diffusing bulb (frosted) lamps in closed receptacles are suitable. In this case the white ceiling redistributes and reflects the light as illustrated in Fig. 7.

As indicated, the outlets above the doorway should be equipped with angle type, porcelain enameled steel reflectors directing the light downward and toward the center of the floor. Those near the peak should have dome type distributing porcelain enamel steel reflectors of a suitable size. The mistake should not be made of using a cheap tin shade of either the flat or cone shape. These will not stand up well in service, the former does not redirect the light effectively, and the latter concentrates it too strongly.

Fig. 7

Night View of Stable Lighted by Two 100-watt White Mazda C Lamps. The pure white ceiling makes reflectors unnecessary. The ceiling height is such as to warrant the use of relatively large lamps

A feature which is a remarkable convenience is a weatherproof diffusing unit hung from a bracket in front of the building, as in Fig. 8. A large Mazda C lamp in this will fill the yard with light making possible the loading and unloading of trucks after nightfall and other duties of this nature. If this is on a three-way switch controlled also from the house and an unusual commotion or noise is heard, the light is thrown on instantly and a possible prowler or marauder is detected.

The dairy shed is usually a much lower building than the barn and requires a somewhat different layout. A row of outlets down the center passage and rows down each rear alley are necessary for feeding, milking and cleaning. If the ceiling is white, 25- or 50-watt MAZDA lamps on 15- or 20-foot centers will provide for the feeding alley. If the ceiling is low, 15-watt MAZDA lamps should be placed in the rear alley opposite the partitions between stalls.

FIG. 8
Night View of a Barnyard and Entrance Lighted by a 500-watt MAZDA C Lamp in a Suitable Weatherproof Reflector. It is of interest to note the safety switch and plug at the left of the doorway for attaching a portable motor to drive a hoist, ensilage cutter and woodsaw

This arrangement will permit light striking the animal from opposite sides and is preferable to locations directly at the rear of the stalls. It is well to have these outlets on several circuits so that only those in the section in which work is being done need be lighted. An arrangement such as described will cause the room to be bright and cheerful and to present the desired sanitary appearance, as well as facilitate and speed up the work.

The walls of the dairy or bottling room are invariably white and offer a fairly good reflecting surface. It is here that the milk is bottled or put up for sale in cans; butter is made and put into print, and in general the room must present a very sanitary appearance, for there is nothing the farmer or his wife are more particular about than the dairy room. What could help more to produce this result

than a neat and efficient lighting installation giving a uniform intensity, and making it possible to carry on dairy work after daylight hours? The standard types of equipment used for industrial or commercial lighting are suitable here. 100-watt units on 8-foot centers will provide the desirable intensity, 8 to 10 foot-candles.

In some instances the interior of the silo has been illuminated by a floodlighting projector, giving a concentrated beam of light, hung from the roof. Care should be taken to keep this clean for when the silo is being filled considerable dust arises. Such a unit should be controlled from a switch at the foot of the ladder and the wiring should be on the outside of the structure. Trouble is likely to result from moisture if the wires are in the interior and not carefully protected.

There are other uses of light about the farm on special occasions which are quite evident. For example, on some progressive farms a truck is fitted with a storage battery of sufficient capacity and on this is mounted an adjustable floodlighting projector which is taken to the fields for use during harvesting and work of a special nature.

In the barnyard and along the lane or driveway small lamps in typical street lighting reflectors, located on poles at what might be termed strategic points, are a final touch in the lighting layout.

Egg Production as Affected by Artificial Light

It may seem strange at first thought that there should be any relation between lighting and production of eggs. On the other hand, there is a logical reason why the proper application of artificial light to lengthen the day should increase production in winter months. The number of eggs produced by the hen is dependent on the activity of the bird and the amount of food consumed. The hen cannot eat at one time more than the crop can hold, and in the normal hen the crop is empty at the end of ten hours.

It is a well established fact that production from a flock is usually decreased in the winter time. This is, without doubt, due to the fact that proportionately more of the 24 hours is spent on the roost; the habits of the birds are such that as soon as the sun sets and the intensity drops below a certain point, they take to the roosts remaining there until sunrise. If we supply artificial illumination so that the period of darkness is reduced to approximately ten hours, in other words, keep the birds active about fourteen hours, they will

have more opportunity for consuming food. By this means it is possible to distribute egg production fairly uniformly throughout the year.

Suitable artificial lighting should be provided in each hen house, with a means of turning this off at a pre-determined time in the evening, after the sun has set, and turning it on at a certain time in

Fig. 9
It is a Comparatively Easy Matter to Milk After Nightfall in a Cow Stable Which Appears as This One Does by Artificial Light. The cows appeared quite blurred in the picture for they moved somewhat during the necessary time exposure

the morning, before sunrise. A thirteen- or fourteen-hour day should be maintained, as soon as the pullets are placed in the laying houses, and continued through March. A longer day causes a heavier production, it is true, but this is followed by a complete molt in the case of hens and a partial molt in the case of pullets, and with either class a cessation of production for a short time. The practice is to keep the hen house lighted until approximately 7:30 or 8:00 p.m., and from 5:00 a.m. until daylight.

Artificial illumination if properly used will thus greatly increase egg production, but may prove injurious to the flock unless proper

conditions, as outlined, are followed. When the use of light is begun in the fall, the change of day must be made gradually by turning on the lamps 15 minutes before the hen would ordinarily get off the roost, and increasing it this time each day until the new schedule is reached. These precautions against such changes are also necessary in the spring when the use of artificial light is to be stopped.

Keeping in mind the fact that hens are made to get off the roost early, so that they can have a longer time to eat, measures must be taken to provide food and water as soon as the lights are turned on. Grit, mash and scratch feed should always be available. The grain

Fig. 10

A Group of Poultry Houses Which Have Proven a Very Good Investment Due to the Fact That Artificial Light Causes Increased Egg Production in the Winter Months

can be scattered in the evening after the chickens have gone to roost and will be ready for them in the morning. Grain should also be given four times a day with a heavy feeding before the lights are turned off, thus assuring the birds going to roost with full crops. Natural spring food may be imitated by providing sprouted oats or other green feed.

It is quite evident that water in an ordinary container will freeze overnight and be of no use to the hens. It is a simple matter to make a device which will prevent the water from freezing; in the bottom of an ordinary water pail a 3-inch hole is cut, a tin can is placed in the pail over the hole and soldered to the bottom of the pail. A small incandescent lamp is left burning within this can. The radiated heat from the lamp will insure water, not ice, for the hens in the morning.

Further details on the question of the proper schedule and feeding will be found in the numerous references in the accompanying bibliography.

To provide suitable artificial illumination for the hen house, relatively small Mazda lamps, proper reflectors and some controlling device are all that is needed. A high intensity of illumination is not necessary; an allowance of one 50-watt Mazda lamp for each 100 square feet of floor area is sufficient. The light should be uniformly distributed over the entire floor space. For the average conditions of spacing and hanging height encountered in this type of building,

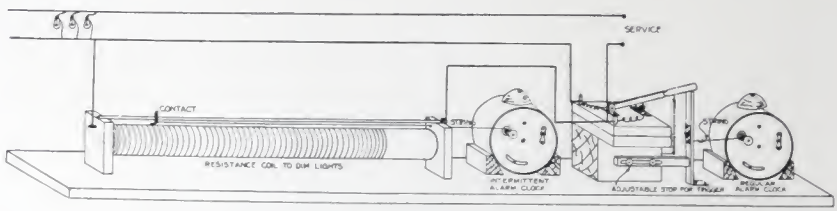

Fig. 11
Sketch of a Home-made Device to Dim and Turn Off Lamps in the Hen House in the Evening and to Turn These on Before Sunrise

the shallow dome metal reflector which distributes the light over a wide angle should be used. Do not make the mistake of using a narrow cone shape reflector, which concentrates the light in a small angle. For a square room, one lamp should be used in the center of the room, but in a long narrow house as pictured in Fig. 12, a row of outlets down the center line should be installed; thus a hen house 10 by 25 feet would be well illuminated by two 40- or 50-watt Mazda B lamps with distributing reflectors, hung close to the roof, and spaced about 12 feet apart.

There are a number of types of automatic devices on the market for turning the lights off and on, but a home-made apparatus as pictured in Fig. 11 will prove satisfactory. This is arranged to turn the light off gradually, imitating sunset and giving the bird an opportunity to get on the roost before total darkness. At the left will be noted an alarm clock of the intermittent type. At the proper time this goes into action, winding the string on a spool, and pulling the contact along the resistance coil. The current flows through this coil, producing a drop in voltage, which dims the light. The end of the tube on which the coil is wound is left blank and this opens the circuit, turning the light off entirely, and permitting no

current to flow. The alarm clock on the right is of the regular type, and when this goes into action in the morning, the spool winds the string, which in turn pulls the hinge support, permitting the spring to close the single-pole knife switch. In the early evening the clock at the left is set to operate at 8:00 p.m., the cord unwound and the contact pulled to the extreme left. The clock at the right is set to operate at 5:00 a.m., the switch opened, the support put in place and the device is ready for automatic operation.

FIG. 12
Night View of the Interior of a Hen House Lighted by Two 50-watt MAZDA Lamps in Distributing Metal Reflectors. Instead of using a dimming device to simulate twilight the practice is followed by turning off the main lights and leaving the small 10-watt lamp, to be seen at the left, burning while the birds get on the roosts

It might be well to summarize conditions which are requisite for success in increasing egg production, through the use of artificial light.

1. Morning light should be used only when feed and water, not ice water, is provided.

2. The chickens should be given a heavy grain diet when the days are artificially lengthened, if a loss of weight is not to result.

3. Increase the day gradually in the fall and do not turn off the light too quickly in the spring.

4. Use the lighting system regularly.

The methods described are by no means an experiment, but have been used by many of the most progressive poultry raisers throughout the entire country, and they are in quite a general agreement that their proper use is a decided economy and a means of increasing profit from the business.

Light and Plant Growth.

The influence of artificial light on the growth of plants has long been a subject of interest to the scientist. As far back as 1861, "Hervé" Mangon found that electric light influenced the formation of chlorophyl in a way similar to that of daylight. Since then, at frequent intervals, experiments have been reported in the technical press. Recently, however, with the development of more efficient light sources such as the MAZDA C lamp there has been a renewed interest in the subject and more tangible results have been secured.

It has been quite definitely proven that artificial light will accelerate germination, increase growth, give greater depth of color and more important still, show no signs of the lanky, unnatural extension of the plant usually associated with forcing. One investigator reports that under artificial light seeds germinated several days, in some cases weeks, before those sown and grown under precisely similar conditions in a control house. The quality of such seedlings is good, stems sturdy and leaves strong, the flowering plants showing an increase in foliage and flowers. It is further indicated that plants grown under artificial light seem to require less heating and the seedlings less "hardening off," before being planted in the open.

Plant physiologists realize that there are many factors affecting plant growth. These include temperature, moisture, carbon dioxide supply, and period of exposure to light. As with any experiment, to determine the effect of varying one element, other factors must be held constant. The control of these factors obviously requires rather elaborate and expensive apparatus. Therefore the results obtained from haphazard experimentation may not tell the whole story. Some results, however, are so striking as to indicate that the period of lighting does have a very definite effect on the behavior of plants.

Messrs. Garner and Allard, physiologists of the Bureau of Plant Industry, Department of Agriculture, have conducted some very interesting experiments on "the flowering and fruiting of plants as

controlled by the length of day." They have found that "the relative length of day is a factor of the first importance in the growth and development of plants particularly with respect to sexual reproduction."

Expressed briefly they determined that each species of plant has certain peculiar habits which are affected by the relative proportion of light and darkness during a day's cycle. Sexual reproduction can only be attained when the plants are exposed to the specifically favorable length of day. A greater length of day will cause certain species to grow more or less indefinitely and not flower or fruit, while causing other types to flower and fruit with less than normal vegetable development. Plants may be either late or early maturing, depending on the length of day to which they are exposed. Several species when exposed to a length of day distinctly favorable to both growth and sexual reproduction have shown a tendency to assume the "ever blooming" or "ever bearing" type of development.

These investigators have further determined that artificial light can be used as a means of prolonging the length of day. This fact should be of much interest to horticulturists and agriculturists.

In a given latitude the length of day at certain times of the year is of course definitely fixed by nature. In summer the day may be longer than required for the particular effect desired (vegetation or fruiting) while in winter it is quite likely to be shorter than desired. By shutting out natural light in summer or supplying artificial light in winter excellent control is possible.

The vital part of the problem is obviously the correlation of data regarding the effects of the various periods on the different varieties or species of plants. The experiments conducted by the investigators above referred to indicate that there is a large group of plants which are brought into the flowering and fruiting stages of development because of the increase in length of day as spring advances into summer. These may be spoken of as "long day plants" in contrast to those which are forced into flowering and fruiting by the shortening of the days in the fall which may be called "short day plants." As a whole there are sharp contrasts between the two groups although there are many plants which may be regarded as occupying an intermediate position. As illustrations of these groups we find in the short day plants, asters, chrysanthemums, dahlias, poinsettias, cosmos and certain varieties of tobacco and beans. In the long day group are most of the so-called winter annuals and most of our common vegetables.

Artificial light properly used to supplement daylight during the short days of winter effectively prevents many of the "short day plants" from flowering and forces "long day plants" into flowering and fruiting. With the proper control of temperature and other important factors of plant growth, there is no reason why almost any plant may not be made to flower and fruit in any season of the year and in any region. With proper knowledge of the specific requirements of each plant the florist should be able to force flowering at any desired time of the year. This is especially practical due to the fact that a comparatively low intensity of artificial light, in comparision with natural light, can be used to supplement the short days of winter. The experiments with artificial light conducted by the Department of Agriculture were based on a very sparing use of artificial light. 40-watt MAZDA B lamps were employed, so spaced as to provide about 1⅓ watts per square foot, giving an intensity in the neighborhood of five foot-candles.

It is evident that the entire question is one of economics. Does the hastening of plant growth, fruiting or flowering, warrant the expenditure for electrical energy? In answer to this, one must make computations applicable to individual instances. In the case of hot house flowers produced out of season or made available for a certain holiday, such as Easter, it is quite evident that the added value of the crop at a particular time will be much greater than the cost of lighting.

There is now no doubt that flowering plants bloom earlier and remain in bloom for a longer time with the proper application of this treatment. Lettuce, for example, responds very effectively to increased illumination and heading has been hastened two weeks in certain cases. Strawberries are reported to grow vigorously and have ripened from two weeks to a month earlier than normal with additional lighting.

Considerable publicity has been given to recent experiments and it is quite logical that the agriculturist is interested in the subject. During the past few months numerous inquiries have been received by lamp manufacturing companies, central stations, etc., as to the possibility of applying artificial light on the farm as a direct aid in increasing the growth of crops. It seems desirable, therefore, to outline certain underlying fundamental facts.

The farmer should not allow his hopes to rise too high as a result of newspaper items. The MAZDA lamp equipped with a suitable reflector to direct the light downward is beyond question the most

efficient light source suitable for this work and we might well make some rough calculations as to the approximate cost of artificial lighting in a given area in order to point out the underlying economic features.

The one point very vital to the whole situation on which we do not as yet have the most definite data is the intensity or amount of light incident on the plant which will produce the most effective

Fig. 13

A Night View of a Greenhouse Lighted by 100-watt Mazda Lamps in Prismatic Reflectors on 13 x 6 Foot Centers. This equipment is efficient and the slight amount of transmitted light makes the interior more cheerful when used, as illustrated, for a flower show. It is evident that artificial light is not of service in hastening the flowering of the plants shown, chrysanthemums, for they are of the "short day" type

growth. The cost of lighting a given area will be in almost direct proportion to the intensity. We measure illumination intensity in a unit termed the foot-candle. This is produced on a surface one foot from a light source of one candle-power. Its value can be judged by holding a newspaper approximately four and one-half feet from an ordinary 25-watt Mazda lamp with no reflector. Must we provide one foot-candle, ten foot-candles or 500 foot-candles to produce the best effect on plant growth?

Intensities out of doors are continually varying, about 0.05 foot-candles in bright moonlight to 10,000 or more foot-candles in an open field on a bright summer day. Intensities of artificial light in the average well illuminated office, for example, vary from five to ten foot-candles, seldom exceeding twenty foot-candles.

Let us suppose that we require only five foot-candles to stimulate plant growth. As a rough general figure a 100-watt MAZDA C lamp, with a suitable reflector, properly hung, would illuminate between 120 and 150 square feet to five foot-candles. The cost of operating such a lamp will vary with the cost of power. At ten cents per kilowatt-hour it would cost one cent per hour. At three cents per kilowatt-hour 0.3 of a cent per hour, and so on. Now to this figure must be added the cost of replacing the lamp when it has burned out and the overhead charges on the reflector, socket, wiring, etc. This additional cost would probably be between 0.1 to 0.2 cent per hour.

Suppose as an extreme case one wished to light a large field to the low value of five foot-candles. One acre contains 43,560 square feet. In other words approximately three hundred 100-watt units would be needed per acre. At the low cost of three cents per kilowatt-hour for power each unit would cost between 0.4 and 0.5 cent per hour to operate. The cost of lighting an acre per hour would be between $1.20 and $1.50; per night of twelve hours between $15 and $18.

It is doubtful that the added growth would be sufficient to justify an expenditure of this order, when we consider the relatively low price of farm products grown on an extensive scale.

In one experiment reported in the technical press a rather high intensity, 700 foot-candles, was used continuously above a plot planted with string beans. This illumination hastened development; in fact doubled the rapidity of growth. Plants bore fruit in a little more than half the time required under daylight alone. From the experimental area three quarts of string beans were gathered which at winter prices represented about 90 cents. The power required at five cents per kilowatt, cost $167. This illustration is introduced to indicate that if the high intensity used by this investigator is necessary, it certainly will not be feasible to raise such a relatively cheap product as string beans by artificial illumination.

Another interesting note recently appeared regarding the effect of light on a relatively large outdoor area. A rye patch was near an

electric street light, so placed that the light fell on the field in the form of a triangle. The rye in the lighted area was approximately four feet and the plants were headed by the time the remainder of the field was a foot high. This was especially striking due to the sharp line of demarcation between the two areas. As rye is essentially a "long day" plant the above effect seems quite logical.

Let us take the other case of where such plants as Easter lilies are placed close together in a greenhouse. A few lamps will light a large number of plants, the product is seasonable and high priced and flowering will be accelerated. In such a case the economics of the situation are entirely reversed and the expenditure for current, lamps and wiring is indeed well justified. If power costs five cents per kilowatt-hour the expense of lighting 1000 square feet would be slightly over one dollar per night. As a typical example, in this area could be placed nearly 2000 Easter lily plants. If by artificial lighting they could be forced a week or two at the critical season, the expenditure for power would be dwarfed by the increase in value.

Between these two extremes occur all the other cases and each question must be settled on its individual merits, but beyond doubt there are many situations where the application of artificial light to lengthen the day is a desirable practice.

With all this work there is quite apparently a limit beyond which the plant cannot be forced, and further study is indeed necessary. While certain flowers, such as tulips, are reported to have longer stems, richer color and larger leaves when exposed to artificial light, others such as petunias, verbenas and primroses, are reported to have been injured.

A comprehensive series of tests now under way on the effect of intensity, color or radiation, stage of growth at which artificial light is applied, temperature, humidity, etc. is most desirable.

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